Impact of Soil Drainage on Growth, Productivity, Cane Dieback, and Fruit Composition of 'Chambourcin' and 'Pinot Gris' Grapevines

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Summary

In the spring and summer of 1997, severe die back of 'Pinot Gris' and 'Chambourcin' grape (*Vitis vinifera*) vines was observed by aerial surveillance in a commercial vineyard adjacent to Lake Erie. Vines grown over the tile lines grew well during 1997-99 following the excessively wet year of 1996. This was not the case for vines that were located between tile lines. It was postulated that by digging and refilling the trench to insert the tile that either soil compaction or soil pH had been altered and could be responsible for the vine performance. Measurements indicated that these factors were not altered enough to explain the growth differences between vines growing over tile lines and those vines growing between tile lines. It appears that soil oxygen was improved by tiling and likely made the difference in cane dieback during the excessively wet year of 1996. By 1999, vines over tile and between tile had similar yields, and the pattern was no longer visible from the air. This study showed that heavy clay soils with naturally poor internal drainage caused cane dieback and poor growth of vines, especially in very wet years. Thus, it appears prudent on soils of this type, tile drainage is beneficial and spacing of lateral tile lines needs to be closer than 40 ft (12 m) in plateau silt loam soils to adequately protect vines from wet years.

In 1996, Ohio experienced one of the wettest years on record and rainfall was above the long term average every month of the year and was particularly excessive and consistently high in the period June through September (Fig. 1).

Soil in Chalet Debonne Vineyard, Madison, OH, near Lake Erie is of the Platea silt loam series and formed on a Wisconsin glacial till plane with sediments of clayey shale and siltstone (USDA Soil Conservation Service, 1973). Platea silt loam contains 22-34 % clay and fragipans can be found from 14.17-25.98 inches (36-66 cm) below the soil surface (USDA Soil Conservation Service, 1973; Zucker and Brown, 1998). This soil series has poor internal drainage during periods of high precipitation and it has been classified in the drainage group E-4 (USDA Soil Conservation Service, 1973). Soils that are composed primarily of clay and silt are more prone to poor infiltration and percolation than soils with a high sand content.

Soil compaction can readily occur during wet periods in which soils are often at field capacity when growers use heavy spray equipment in the spring or remove fruit at harvest. As equipment repeatedly passes over the same area in vineyard there is a greater potential for soil bulk density to increase. Few grape growers implement some type of drainage program to encourage drainage and lower the water table to enhance trafficability of equipment in fields.

Vine vigor and productivity have been shown to improve by the use of field tile in Ontario, Canada (Fisher, 1997). An increase in plant vigor appeared to be related to improved soil drainage and possibly due to an increase of oxygen in the root zone. Stressed grapevines could result in low root volume which may limit carbohydrate reserves and hormone levels which could lead to increased winter injury and result in poor shoot emergence (McArtney and Ferree, 1999 a & b).

In an attempt to determine what caused the distinct difference in vine growth, a study was established to evaluate the differences in the vines and soil immediately over the tile lines and vines and soil in the center between the lines. A separate study was conducted in the 'Pinot Gris' and 'Chambourcin' vineyards which were adjacent.

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Materials and Methods

Site: The vineyard site at Chalet Debonné Vineyards was tiled with diagonal laterals to the field edges (USDA Soil Conservation Service, 1973) in 1992 using 4-inch (10-cm) diameter tile spaced 40 ft (12 m) apart (Fig. 1).

Plant Material. 'Chambourcin'/Couderc 3309 (3309C) (planted in 1995) and 'Pinot Gris'/Couderc 3309 (3309C) (planted in 1994) grapevines from Chalet Debonné Vineyards at Madison, Ohio were used in this study. Grapevines were selected according to their position to tile lines, and they were either over a tile or midway between two lateral tiles (Fig. 1). All grapevines were trained to a low cordon (30 in (76 cm) from ground) and vertically shoot positioned. One-year-old canes were pruned to three to four nodes/spur.

Data Collected. Data were recorded on plant performance including weight of cane prunings, yields, cluster and berry weights, and fruit composition in 1998 and 1999. Penetrometer (The Investigator Soil Compaction Meter, Spectrom Technologies, Inc., Plainfield, Ill. readings were recorded at 2-in (5 cm) intervals to a depth of 16 in (40cm) in the row 12 in(30 cm) from the vine, in the equipment track, parallel to the row and in the row center. Five oxygen probes were inserted at 6- and 18-in depths (15 and 45 cm), 12 in (30 cm) from each vine (Oxygen Diffusion Ratemeter, Model D, Jenson Instruments, Tacoma, Wash.) in the soil. Soil samples were collected 12 (30 cm) inches from each plant at 6, 12, and 18 inches (15,30,45 cm) deep to determine soil relative water content and pH. Pentrometer, oxygen readings and soil samples were taken in April 1999 with the soil moisture at field capacity.

Experimental Design and Analysis. The treatments were made using a completely randomized design with seven replications per treatment in 'Chambourcin' and 'Pinot Gris' vineyards. Data from each vineyard were analyzed using SAS statistical package (SAS Institute, 1996) with mean separation by LSD.

Results and Discussion

Vine Growth and Production. Pruning weight of live and dead wood from 'Chambourcin' grapevines grown over tile were not significantly greater than vines not located near a tile (Table 1). 'Pinot Gris' grapevines grown over tile had a significantly higher amount live and dead pruning wood than vines not tiled (Table 1). Live and dead pruning wood were higher for both cultivars in 1999 than in 1998.

Yield of 'Chambourcin' were also significantly greater on grapevines grown over tile compared to vines not located near tile. Cluster weight of 'Pinot Gris' was higher in 1999 than in 1998. Yield in 1999 was higher for both cultivars compared to 1998 and proximity to the tile line had no effect on yield in 1999. Tiling significantly increased the berry weight in 'Chambourcin', but had no significant influence on 'Pinot Gris' berry weight. In the study conducted by Fisher (1997) yields in tiled areas were greatly increased over nontiled areas. Vine growth and productivity increased to a greater extent in response to tiling in poorly drained field than in well drained fields. This study supports the results found by Fisher (1997) that it is important to remove excess water from the soil profile to improve vine productivity.

The significant differences in 1999 and 1998 data could be attributed to the time required for the vines to recover from the 1996-97 wet conditions (Fig. 2) and subsequent winter damage. By 1999, most of the vines were reestablished on the trellis. Both 'Chambourcin' and 'Pinot Gris' were grown on '3309C' rootstock which has been determined to be a good rootstock for heavier clay soils and Ohio growing conditions (Ferree et al., 1996).

Fruit Composition. Juice made from 'Chambourcin' and 'Pinot Gris' did not differ in total soluble solids (TSS), pH, and titratable acidity (TA) when comparing tiled versus non-tiled grapevines (Table 1). Soluble solids and TA of 'Chambourcin' fruit were higher in 1998 than in 1999, which was likely due to the lower crop in 1998. No significant differences were found in pH of 'Chambourcin', however pH of 'Pinot Gris' fruit was significantly greater in 1999 than 1998 (Table 1). In this study, fruit composition was more influenced by growing season and crop level than by soil moisture. Environmental factors including sunlight, temperature, and rainfall probably had a greater impact on fruit quality than the soil moisture content.

Soil pH and Relative Water Content. Soil in the 'Chambourcin' and 'Pinot Gris' vineyards showed a significant decreasing linear relationship in pH with depth of the soil profile (Table 2). There was no difference between the pH of the control soil sample and the sample taken over the tile lines in the 'Chambourcin' vineyard. In the 'Pinot Gris' vineyard, however, pH of the soil that had been mixed when the tile was installed was higher than the pH of the undisturbed soil between tile lines. The soil in the 'Pinot Gris' vineyard was less acidic overall than the 'Chambourcin' vineyard. There was no interaction between tilage and soil depth.

Relative water content (RWC) in the 'Chambourcin' vineyard decreased down through the soil profile. However, RWC in the 'Pinot Gris' vineyard was higher at 12 in (30 cm) than at either 6 or 18 in (5 or 45 cm) (Table 2). Since the Platea soil is known to have fragipans, these impervious layers may have reformed after the tile lines were established resulting in an increase in % relative water content at 30 cm. There was no significant difference in soil relative water content between tiled versus non-tiled soil in either vineyard, which indicated that there was no evident tiling affect on soil drainage or water holding capacity (Table 2). However, this likely was very different in 1996 with the very wet conditions and the tile would result in facilitating removal of excess water from the soil profile.

Soil Compaction. Soil compaction as measured by penetrometer was significantly greater in the equipment track than in the soil around the plants in both vineyards, except at the 20cm level in the 'Pinot Gris' vineyard where there was no significant difference (Table 3). Track and aisle compaction were significantly different at each soil level, except for the 2, 14, and 16 in (5, 35, and 40 cm) levels in the 'Chambourcin' vineyard, and the 14- (35 cm) and 16-in (80 cm) levels in the 'Pinot Gris' vineyard. These results would support the concept that repeated passes of equipment through the vineyards caused increased soil compaction in the track area. The compaction could severely reduce water percolation through the soil profile in the tracks. When considering the entire soil profile in the plant area, there does not appear to be a problem with compaction (Table 3). Tiled areas tended to dry much quicker than nontiled following heavy rains and this was also the case in the study conducted by Fisher (1997). Well drained soils will undoubtedly provide greater trafficability when producers are spraying in early spring and harvesting in the fall.

Soil Oxygen. Soil over the tile lines had higher soil oxygen levels than soil in between tile laterals (Table 4). No significant difference was found between the oxygen levels in soil of the 'Chambourcin' and 'Pinot Gris' vineyards. Oxygen levels were higher at the 6 in (15 cm) level than at the 18 in (45 cm), but the differences were not significant. The significant increase in the amount of oxygen that was found in the root zone of the vines grown over tile may have provided an important component in vine survivability. Since soil aeration is important for good root growth, the significant increase in oxygen of tiled soils may have increased root system growth of vines grown over tile. It has been reported that the amount of root volume can have an important influence on vine growth and productivity (McArtney and Ferree, 1999b).

Conclusion

Vines that grew very poorly following the excessively wet year of 1996 recovered by 1999. The diagonal pattern observed in 1997 was no longer visible in 1999 and vines over tile and between tile lines had similar yields. Prior to our study it was postulated that by digging and refilling the trench to insert the tile, either soil compaction or soil pH had been altered and could be responsible for the vine performance. Measurements indicated that these factors were not altered enough to explain the growth differences. It does appear that soil oxygen was improved by tiling and this was likely much greater in the excessively wet year resulting in improved vine growth. Although this vineyard is an excellent grape site because of its proximity to Lake Erie with its moderating effect on temperatures, the heavy clay soil caused a problem in vine growth, especially in very wet years. Thus, it appears prudent on soils of this type, tile drainage is beneficial to vines immediately over or adjacent to the lines and spacing of the laterals needs to be closer than 40 ft normally recommended to adequately protect vines in wet years.

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Table. 1 Influence of tiling on yield, cluster size, berry weight, and fruit chemical analysis of 'Chambourcin - and'Pinot Gris'at Chalet Debonné Vineyards in 1998 and 1999.

	Pruning[z]					Fruit composition		
	Live wt. lb	Dead wt. lb	Average Cluster wt. lb	Yield lb/vine	Berry wt. (g)	TSS[y] (%)	pH	TA[x] ($g \cdot L^{-1}$)
				'Chambourcin'				
Treatment								
Non-tile	1.04	0.07	0.37	27.3 b	1.90b	20.7	3.14	10.4
Tile	1.62	0.10	0.42	37.2a	2.10a	20.7	3.14	10.4
Year								
1998	0.94b	0.03b	0.34b	20.7b	2.03	22.0a	3.17a	11.1a
1999	1.72a	0.13a	0.45a	44.6a	1.97	19.4b	3.10b	9.8b
				'Pinot Gris'				
Treatment								
Non-Tile	0.53b	0.03b	0.20	19.9	1.45	17.8	3.33	06.0
Tile	1.04a	0.07a	0.20	22.3	1.50	18.4	3.29	06.2
Year								
1998	0.32b	0.03b	0.19b	15.6b	1.68a	18.7	3.28b	06.2
1999	1.25a	0.07a	0.22a	26.6a	1.27b	17.5	3.35a	06.1

[z]Data followed by different letters are significantly different at LSD P $\leq$0.05.
.[y]Total Soluble Solids
[x]TA = titratable acidity % tartaric acid.
[w]28.35 g = 1.0 oz, 1.00 lb = 0.454 Kg, 1.0 gL^{-1} = 1000 ppm

Table 2. Influence of soil tiling on soil pH and relative water content at three depths at Chalet Debonné Vineyards in spring 1999.

	'Chambourcin'		'Pinot Gris'	pH
Treatment	**pH**	**RWC^z%**		**RWC%**
Check	4.92	17.9	5.28b	18.8
Tile	5.00	17.8	5.91a	17.8
Depth [inches (cm)]				
6 (15 cm)	5.2	19.0	6.1	17.8
12 (30 cm)	4.9	18.4	5.6	19.6
18 (45 cm)	4.8	16.2	5.0	17.6
Linear	**	**	**	NS
Quadratic	NS	NS	NS	*

**,* Data are significantly different LSD at P $\leq$0.01 and 0.05, respectively.
^{z}RWC = relative water content = (wet weight - dry weight) ÷ wet weight

Table 3. Soil penetrometer values (lbs/in^2) in ‘Chambourcin’ and ‘Pinot Gris’ vineyards at Chalet Debonné Vineyards comparing the effect of tiling and location relative to the vine.

	Pentrometer values in lb/inch^2 at 2-inch intervals of soil depth								
	2	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**Average compaction**
					‘Chambourcin’				
Treatment									
Non-tile	177	181	212	218	249	340	507	630	314
Tile	245	231	269	256	234	380	517	583	356
	NS	NS	NS	NS	NS	NS	NS	NS	NS
Location									
Plant	117b	113b	156b	166b	201b	286b	406b	507b	244b
Track	243a	349a	343a	351a	493a	512a	601a	633a	439a
Aisle	223a	165b	222b	193b	229b	283b	528a	688a	313b
					‘Pinot Gris’				
Treatment									
Non-tile	206	207	217	176	210	306	429	514	283
Tile	158	178	188	196	221	271	368	448	283
	NS	NS	NS	NS	NS	NS	NS	NS	NS
Location									
Plant	103b	77b	147b	179ab	156b	176b	199b	305b	168c
Track	271a	363a	341a	270a	339a	446a	494a	545a	384a
Aisle	171b	139b	120b	108b	152b	242b	502a	593a	253b

[z]Data followed by different letters are significantly different LSD at $\underline{P} \leq 0.05$.
[y]1 inch = 2.54 cm; 1 lb/in^2 = 6.89 KPa

Table 4. Influence of tile on soil oxygen level under 'Chambourcin' and 'Pinot Gris' cultivars in spring 1999.

Treatment	**Diffusion Rate**[z] **$\mu \cdot cm^{-2}$**
Check	.179a
Tile	.226b
Cultivar	
'Chambourcin'	.186
'Pinot Gris'	.218
Depth	
15 cm	.218
45 cm	.186

[z]Data followed by different letters are significantly different LSD at $\underline{P} \leq 0.05$, ($\mu \cdot cm^{-2} \cdot min$) .850 = $grains.ft^{-2}.hr^{-1}$